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Growing White Pine in the Lake States to Avoid Blister Rust

By
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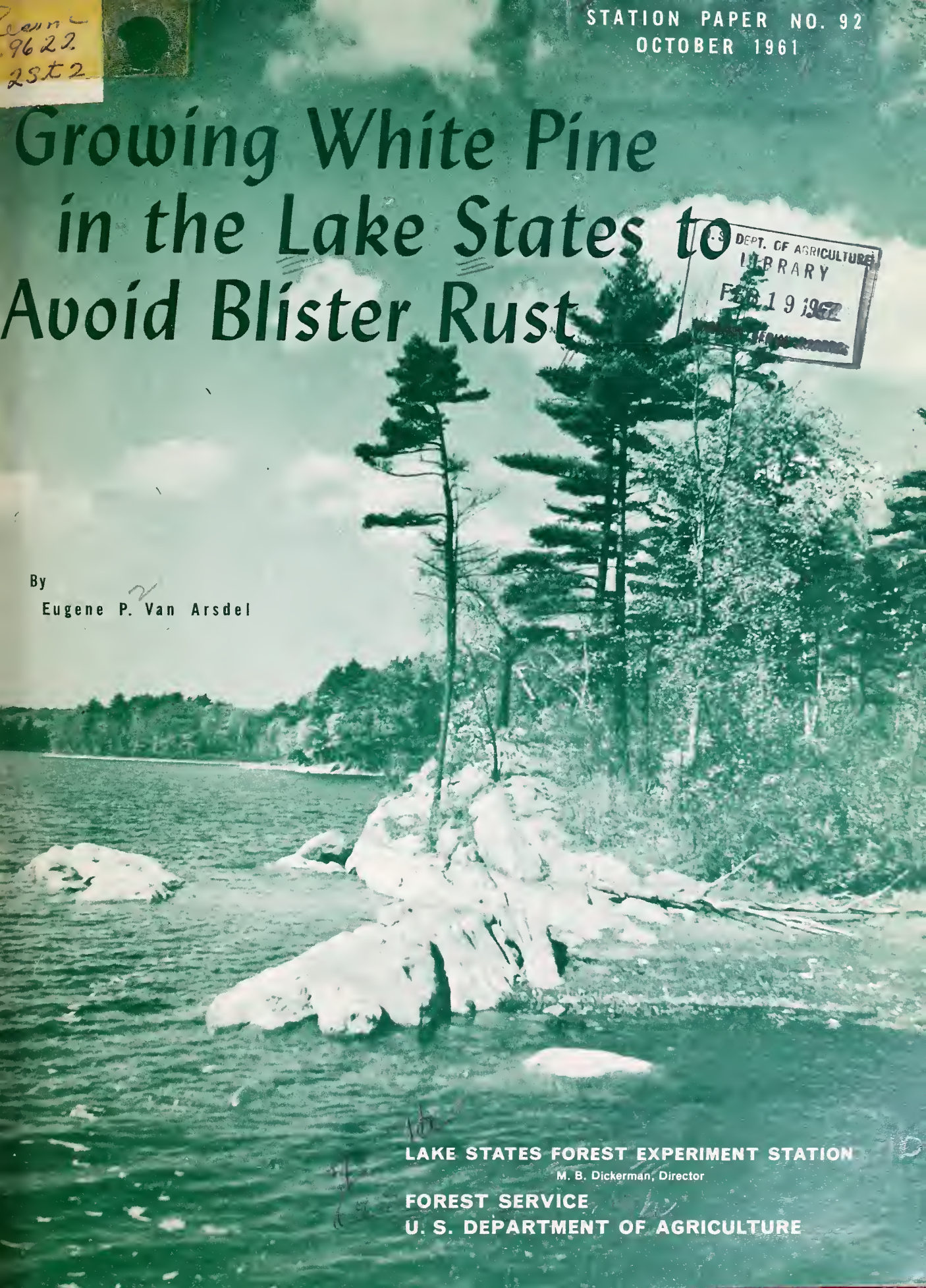

LAKE STATES FOREST EXPERIMENT STATION
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FOREST SERVICE
U. S. DEPARTMENT OF AGRICULTURE

Foreword

Material presented here is the result of studies conducted by the Lake States Forest Experiment Station, U.S. Forest Service, in cooperation with the Wisconsin Agricultural Experiment Station, University of Wisconsin.

Much of the information on control procedures for white pine blister rust will also appear in a Forest Pest Control Leaflet to be published by the Wisconsin Conservation Department. The present paper, however, designates rust protection zones for Minnesota and Michigan, which are not included in the Wisconsin leaflet. It also provides more background on the derivation of the control procedures for the benefit of research foresters and others who may be interested.

Acknowledgment of advice and assistance in developing control methods is due A. J. Riker and R. F. Patton of the Department of Plant Pathology and V. E. Suomi and R. A. Bryson of the Department of Meteorology, University of Wisconsin; and T. F. Kouba at the U.S. Forest Service Regional Office in Milwaukee. Special help in delineating control zones was given by A. W. Depta, R. G. Doerner, L. E. Nelson, L. B. Ritter, S. M. Sager, and R. Weber of the U.S. Forest Service, Division of Pest Control.

CONTENTS

Growing White Pine in the Lake States to Avoid Blister Rust

by

Eugene P. Van Arsdel[1/]

White Pine

Since white pine is one of the most desirable tree species for the Lake States region, it is unfortunate that fear of the blister rust disease has greatly limited the amount of white pine planted. Research has shown that, in many areas, loss from the disease has not been great even where pine stands have not been protected through ribes eradication. Conversely, in other parts of the Lake States, present control through eradication has not worked as well as is desirable.

This paper presents procedures for specialized blister rust control that will permit growing white pine with minimal losses to rust at the lowest possible protection costs presently available.

Blister Rust

Blister rust is a fungus disease that goes through five spore stages and utilizes two hosts to complete its life cycle (fig. 1). Many events can break the chain of this life cycle, and chances of a particular spore starting a new generation are extremely small. But because vast quantities

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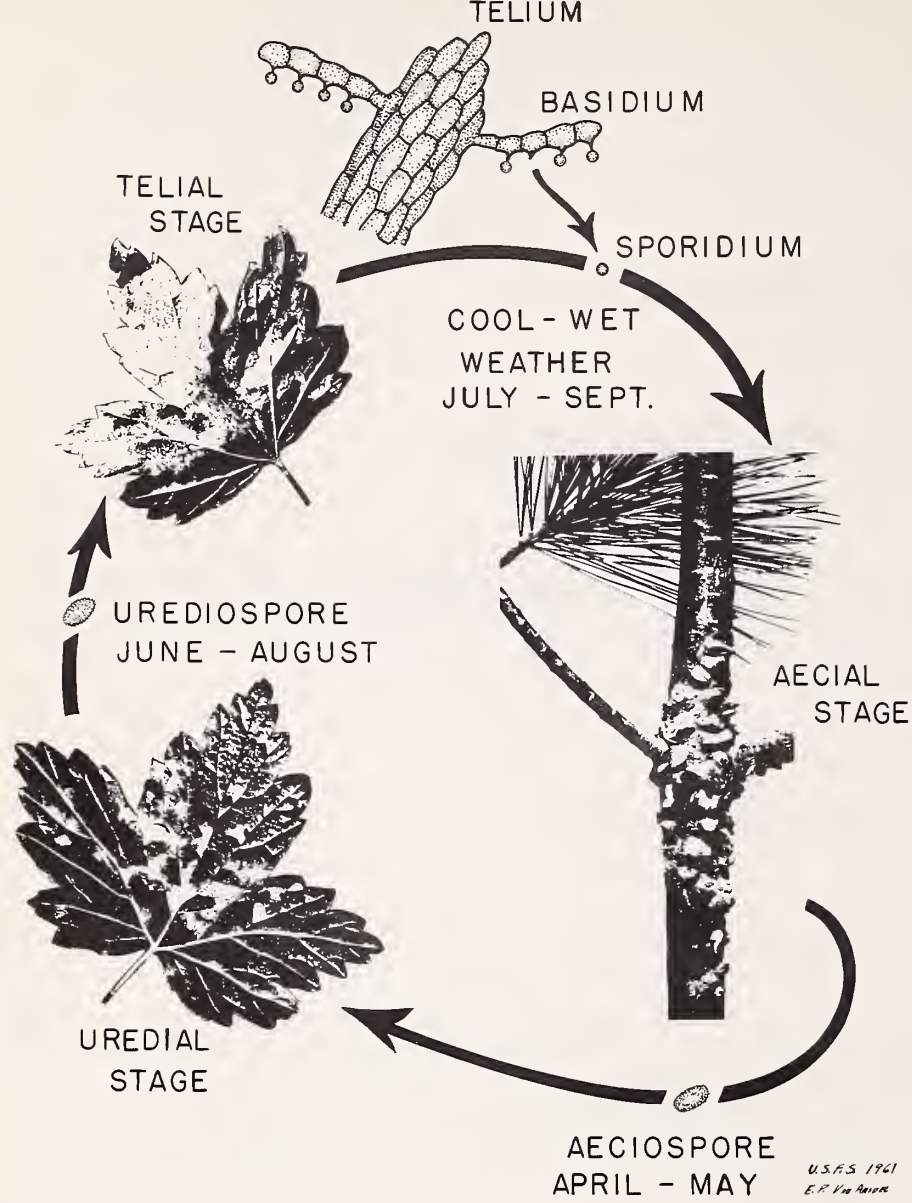

Figure 1.--Life cycle of white pine blister rust in the Lake States. Uredial and telial stages on Ribes nigrum L.

(billions) of spores are released, the fungus is able to overcome these obstacles to spread and survival. Under some climatic conditions, however, even this vast spore production is not enough to ensure increase of the disease. For example, infections on pine are rare in relatively warm-dry areas of the southern parts of the Lake States. In other areas, eradicating the gooseberries and currants in the vicinity of white pines is effective in preventing blister rust spread. In areas that are particularly cool and wet, however, eradication alone is insufficient to control rust.

Factors Influencing Control

Control measures for white pine blister rust include eradication of the alternate host, ribes (gooseberries and currants); the use of

white pine trees resistant to the fungus; the eradication of established cankers by pruning or antibiotics; and climatic escape. Of these, resistant trees are not yet ready for release, and practical methods for using antibiotic chemicals have not yet been developed for the Lake States. Until the past few years, control has depended almost entirely on eradication of the alternate host. Recent advances in research have resulted in cheaper and better methods by using climatic escape as an aid to control.

Climatic escape as used here refers to the selection of sites and manipulation of stands so that the environment is unfavorable to the survival of the blister rust fungus. Certain temperature and moisture conditions and spore transportation are necessary for the spread of blister rust from ribes to white pine. The pines can escape infection by the rust if any essential environmental factor is unfavorable.

Conditions Necessary for Spread of Rust

The use of climatic escape as an aid to rust control is dependent on an intimate knowledge of the effects of weather on the rust fungus and considerable knowledge of the effects of vegetation and topography on local climate. A brief review of weather necessary for rust spread and of possible limiting environments is given below. The stages in the rust's life cycle that are most sensitive to these limiting factors are the teliospore stage and the subsequent transfer of the fungus from the teliospore on the ribes to the needle of the pine by the airborne sporidium (fig. 1).

Teliospores are formed on gooseberry and currant leaves from about July 15 to September 15. The cooler the summer, the longer the period with teliospores present. Fertile teliospores are formed after 2 weeks of cool weather. Sporidia are the small (10 to 12 microns diameter), clear spores that carry the rust from the teliospore to the pine tree. Sporidial production and germination require more than 48 hours of temperatures less than 20° C. (68° F.) and abundant moisture constantly available (4, 6).[2/] Release of rust sporidia occurs at night, and present indications are that they are released on clear nights after long, wet periods (3). Young needles on current pine growth and young stems (new shoots) are more susceptible than old, hardened-off needles (4).

Temperature Effects

Blister rust is more abundant on pines in areas with low daily maximum temperatures or with long daily cool periods; such areas have fertile teliospores more frequently and hence can produce sporidia in wet weather.

2/ Underlined figures in parentheses refer to literature cited at the end of this paper.

Daily maximum temperatures are lower at higher latitudes and higher elevations. Prolonged cool periods also occur in areas with a negative radiation balance (such as a small opening in the crown canopy) all or part of the day. A negative radiation balance refers to an area where outgoing radiation (such as cools the earth at night) continues during the day, while incoming solar radiation is stopped by shading from the sides. In tree planting in the warmest parts of the Lake States, rust infection can be minimized by avoiding such cool sites (5, 7).

Moisture Effects

The principal limiting factor on rust infection in the Lake States is lack of sufficient moisture. But even in wet weather the trees cannot be infected unless the temperature is right. Therefore, temperature also limits infection. The more moisture available under a given set of conditions, the more likely that there will be wet periods at times of favorable temperatures.

High humidities, resultant from greater rainfall and reduced evaporation (at lower temperatures), are found at higher elevations. Reduced evaporation is also found with increased latitude and the related decrease in temperatures.

Some local areas, such as small openings in the forest, have higher humidities and are wet longer than surrounding areas because of a number of conditions. When a given air mass with a given water content is cooled by a negative radiation balance, the relative humidity will be higher. Such cool spots have downdrafts that introduce more warm air, which in turn gives up moisture as it is cooled. In such spots leaves losing heat through outward radiation are cooler than the surrounding air. Often the leaf temperatures are lower than the temperature of the dew point for several hours a day and, therefore, remain wet for this longer period. There is also some evidence that winds cause greater rain deposit in forest openings than in solid forest or open fields.

Conversely, leaves of pines under the crowns of a suitable tree overstory are not cooled more than the surrounding air. Dew does not form on these understory leaves even at night. Instead it forms on the tops of the overstory leaves, which are cooled by outward radiation to the open sky.

Hence, pines in a small opening have much rust because of high available moisture, while pines under a closed tree canopy have the least rust of any site because of low available moisture on the leaves (2).

Spore Transportation

At times rust infection is limited by failure of the rust spores to reach the pines. White pines near certain ribes-infested swamps in northeastern Wisconsin were seldom infected, while those on more distant ribes-free higher ground were heavily infected. Smoke movements indicated that nighttime thermal circulations would carry spores to the pines on the higher ground rather than to the closer ones on lower ground (1). Other smoke-movement patterns indicate that planting strips of barrier trees or leaving residual strips of trees between clear-cut zones should create thermal circulation barriers to spore transport between ribes patches and pine stands (8).

Effect of Shoot Age

At higher elevations and latitudes, rust is favored by low temperatures, high relative humidities, and by relatively early-in-the-season release of sporidia while young shoots on the pines are still in a highly susceptible condition (4).

Growing White Pine to Avoid Blister Rust

A number of aids to growing white pine with a minimum of loss to rust and a minimum cost for control have been developed. Although some of these aids are still receiving additional testing, they are based on sound micrometeorological theory and, if applied under the proper circumstances and in the right combinations, can be used with confidence that 95 percent of the trees will remain rust-free.

Aids to Control for All of the Lake States

1. Maintain a closed canopy. Grow pines so branches soon touch and maintain a uniform closed canopy. This keeps the air dry below the canopy. Susceptible or cankered side branches are shaded off sooner.

2. Prune off lower branches. Keep crop trees pruned so the lower one-third of the stem is free of living branches. Since the source of moisture allowing most infections is re-evaporated rainwater from the soil, more than 99 percent of all blister rust cankers in the Lake States are within 6 feet of the ground.

3. Avoid small openings. Do not plant as a fill-in in small openings in an overstory canopy. Openings in the crown canopy with a diameter less than the height of the surrounding trees are cool and wet. These conditions favor rust infection.

Specialized Aids for Particular Sections of the Lake States

To help in blister rust control, the Lake States have been divided into four zones (fig. 2). The zones are tentative, and since the climatic gradation is gradual, exceptions are more common near zone lines. In figure 3, a special zone map of Wisconsin is included. It is more accurate than the map for the Lake States as a whole.

For each of the four zones, a separate set of rust-control aids, tailored to fit the needs of that part of the Lake States, is suggested below.

Zone 1--lowland south and lowland central region. (Unshaded area in figs. 2 and 3--contains all land under 1000 feet above sea level except along the Lake Superior shore and northern Lake Michigan and Huron shores.) For this zone, the following rust-prevention methods are recommended:

a. Grow pine with no control. With no control, losses due to blister rust should be less than 5 percent.

b. To reduce losses to a lower level, use aids recommended for the whole State.

c. To avoid essentially all losses, use control practices outlined for zone 2.

Zone 2--south central midlands. (Stippled area in figs. 2 and 3--contains most land 1000 to 1200 feet elevation and northern Lake Michigan and Huron shores.) For this moderate-hazard area, the following controls are recommended:

a. Eradicate gooseberries and currants in pine areas and all areas where cold air flowing downhill would drain into the pine area. Edge eradication (75 feet in from edge) is sufficient for solid canopied woodlots.

b. Avoid planting sites where cold air collects at night and outward infrared radiation continues while side shade prevents incoming solar radiation (fig. 4). Avoid: Bottoms of V-shaped valleys; kettle holes; bases of slopes; small openings in forests, such as an opening created where one oak tree has died or been cut; and selectively logged or shelterwood cut stands.

c. Do plant on these sites with comparative safety: Under solid oak canopies on sandy or dry ridgetop sites, in open fields, on steep slopes, on hilltops, and on hill shoulders.

d. To keep losses at a lower level, use control outlined for zone 3.

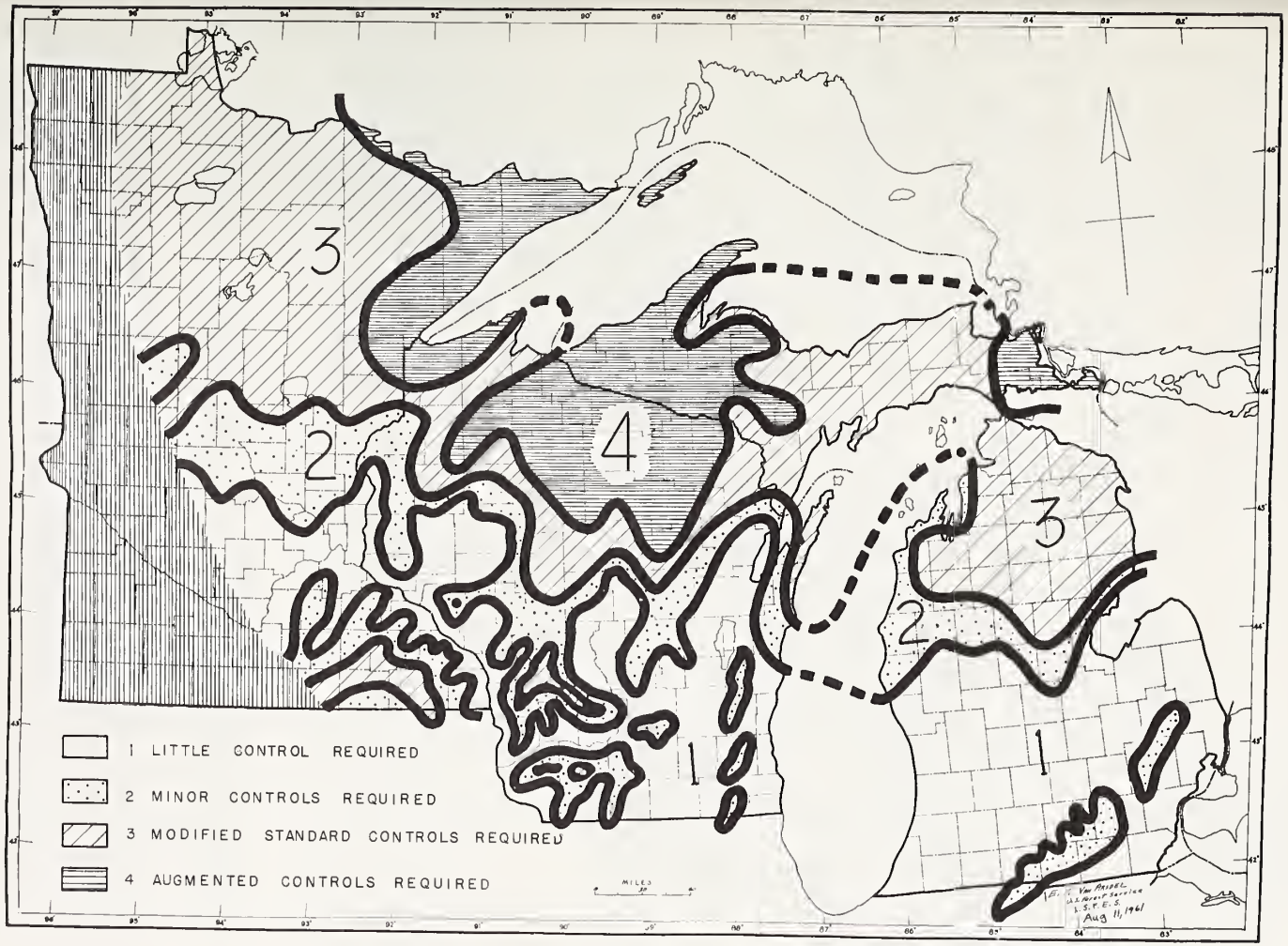

Figure 2.--White pine blister rust hazard zones in the Lake States. Exceptional rust spread is more common in areas near the lines between the zones. Revisions will be made as more rust distribution surveys are made.

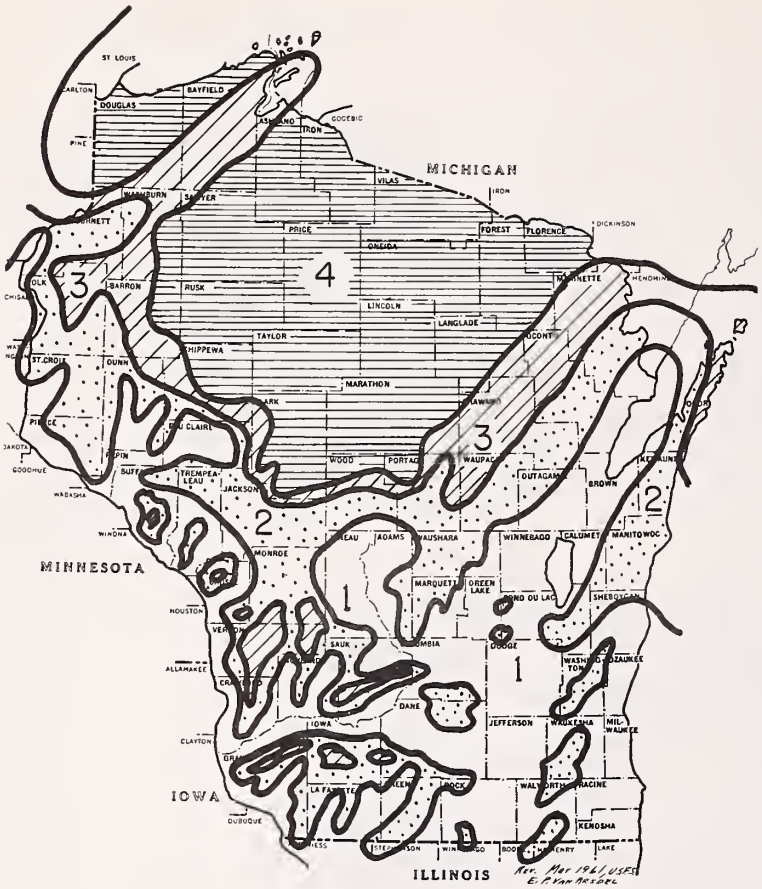

Figure 3.--A more detailed map of white pine blister rust hazard zones in Wisconsin. This is based on more surveys than the Lake States map and is more reliable.

Zone 3--northern zone. (Diagonal shaded area in figs. 2 and 3--northern area less than 1400 feet above sea level away from cold lake shores, and southern areas above 1200 feet.) For this area, use standard rust-control procedures outlined in "Blister Rust Control Field Manual for the North Central Region," U.S. Forest Service, Milwaukee, Wis., with the following aids:

a. Eradicate or poison ribes within 900 feet of pines, except where solid overstory canopy covers ribes; then eradicate 100 feet into the edge of the stand.

b. Eradicate a 100-foot-wide strip into wooded swamps of alder, cedar, tamarack, and spruce-fir, but not open sedge marshes.

c. Plant only under overstories as outlined for zone 4 or in ribes-free areas.

d. To keep losses to an absolute minimum, use recommendations for zone 4.

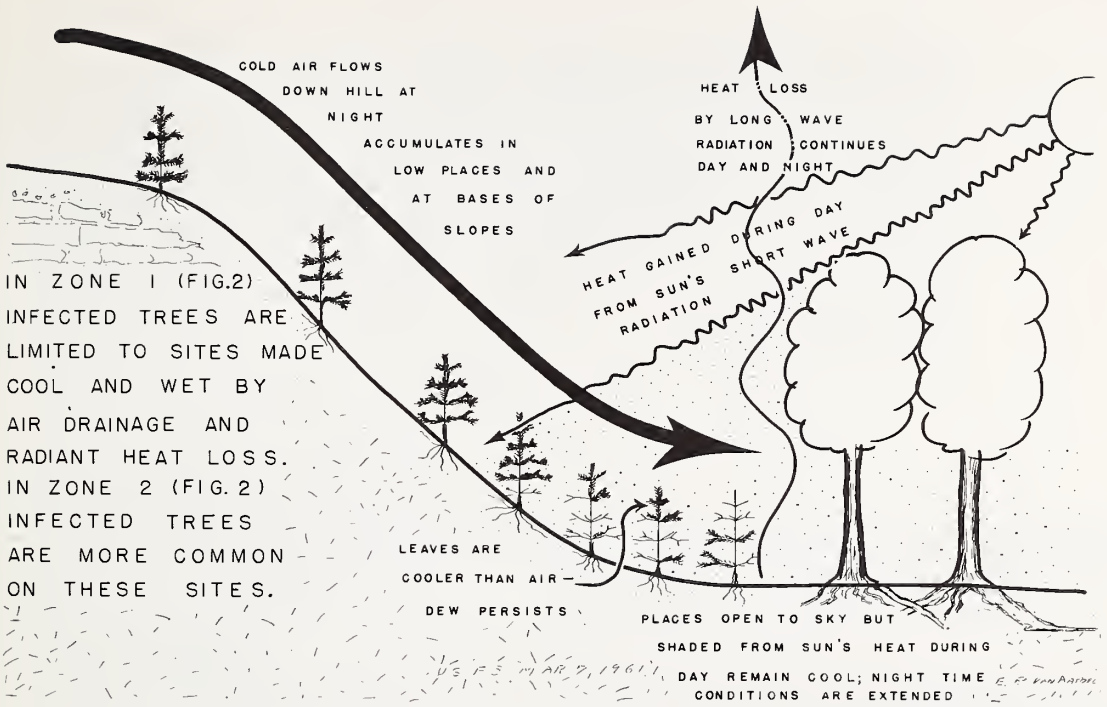

Figure 4.--Two processes (air drainage and local radiant heat loss) that result in local cool-moist areas favorable to rust spread in zones 1 and 2.

Zone 4--northern highland and northern lake shores. (Horizontal shading in figs. 2 and 3.) Blister rust spreads long distances in this zone, and the following special precautions are necessary:

a. Maintain an overstory cover of oak (on sand), aspen, paper birch, or jack pine to reduce blister rust. In release cuttings, make no openings larger than a single aspen or paper birch crown, and make these only in trees pole size (6 inches d.b.h.) and larger.

b. Keep pine areas large to warrant the large costs of control.

c. Do not plant blister-rust-susceptible white pine unless planting is part of a management plan to better a large block of white pine already protected from disease. Blister-rust-resistant white pine suitable for planting in the northern highland zone should be available in the future.

d. Plant only under overstories as outlined in 4a when filling larger pine areas to increase value. Hybrid poplars should become available to obtain quick overstories.

e. Eradicate ribes across all open areas to 100 feet into the woods no matter how distant the wooded area.

f. Establish barrier strips by cutting trees and leaving a residual strip between clear-cut areas or by planting a few rows of trees in open areas between pine and ribes concentrations (see fig. 5). Air circulation around such a strip should greatly reduce spore transport. Open strips, each side of barrier, must be at least two or three times the height of the intervening trees. (Ribes in barrier strips must be eradicated.)

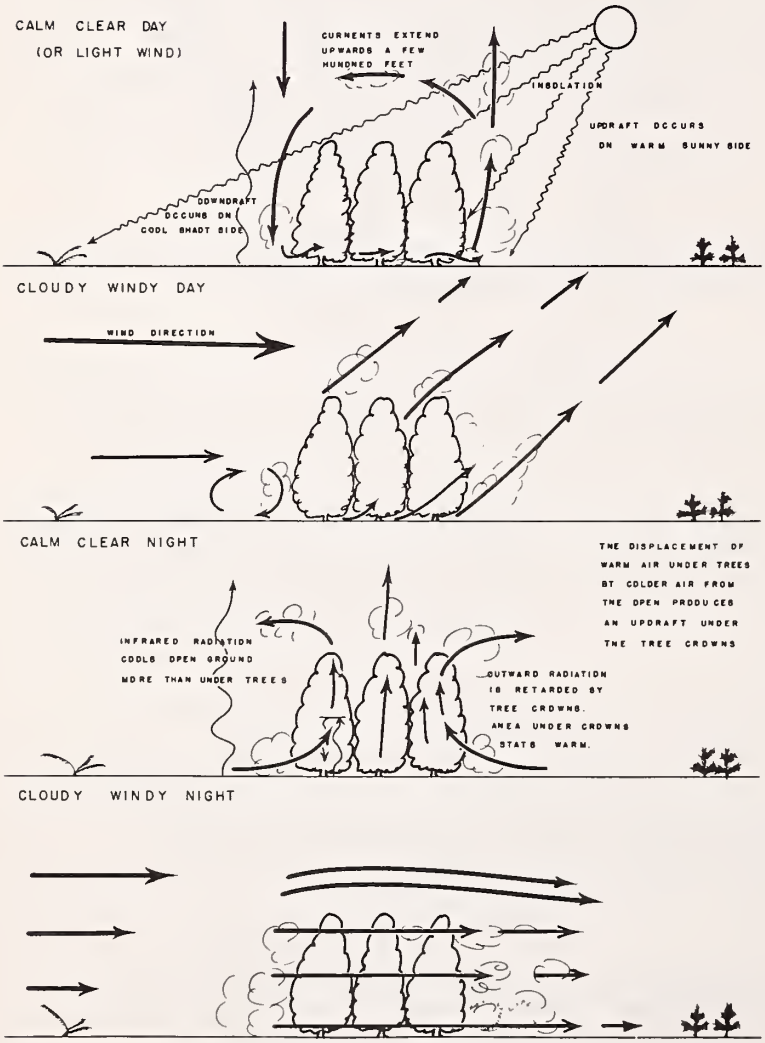

Figure 5.--Some representative effects of a windbreak or row of trees on airflow. Such a "barrier strip" impedes rust spread in extra-favorable spread weather in zone 4.

Using these recommendations should permit growing white pine throughout the Lake States with only light losses due to blister rust infection. Following these rules for escaping rust will permit freer use of white pine in these States and encourage the use of white pine for reforestation. In most cases, special help from Federal or State Blister Rust Control personnel will be needed in protecting white pines from blister rust. Write to the U.S. Forest Service, Blister Rust Control Office, in care of the State Entomologist at the State Capitol.

Literature Cited

1. Van Arsdel, E. P.
   1958. Smoke movement clarifies spread of blister rust from ribes to distant white pines (Abs.). Bul. Amer. Met. Soc. 39: 442-443.

2. _____ and Riker, A. J.
   1958. Climatic relations of white pine blister rust. In Ann. Rept. on Diseases of Forest Trees, Univ. Wis., pp. 5-7. (Processed.)

3. _____ and Riker, A. J.
   1959. Climatic relations of white pine blister rust. In Ann. Rept. on Diseases of Forest Trees, Univ. Wis., pp. 4-7. (Processed.)

4. _____ and Riker, A. J.
   1960. Blister rust fungus inoculations on white pines in mist chambers (Abs.). Phytopath. 50: 657.

5. _____, Riker, A. J., and Patton, R. F.
   1953. Microclimatic distribution of white pine blister rust in southwestern Wisconsin (Abs.). Phytopath. 43: 487-488.

6. _____, Riker, A. J., and Patton, R. F.
   1956. The effects of temperature and moisture on the spread of white pine blister rust. Phytopath. 46: 307-318, illus.

7. _____, Riker, A. J., Kouba, T. F., Suomi, V. E., and Bryson, R. A.
   1961. The climatic distribution of blister rust on white pine in Wisconsin. U.S. Forest Serv., Lake States Forest Expt. Sta., Sta. Paper 87, 34 pp., illus. (Processed.)

8. _____, Tullis, E. C., and Panzer, J. D.
   1958. Movement of air in a rice paddy as indicated by colored smoke. Plant Dis. Rptr. 42: 721-725, illus.

SOME RECENT STATION PAPERS
Lake States Forest Experiment Station

Trends in the Wisconsin Charcoal Market, by John R. Warner and Burton L. Essex. Sta. Paper 80, 22 pp., illus. 1960.

Proceedings of the Lake States Forest Tree Improvement Conference, October 6 and 7, 1959. Sta. Paper 81, 60 pp., illus. 1960.

Michigan's Forest Resources, by Virgil E. Findell, Ray E. Pfeifer, Arthur G. Horn, and Carl H. Tubbs. Sta. Paper 82, 46 pp., illus. 1960.

European Pine Shoot Moth Damage as Related to Red Pine Growth, by H. J. Heikkenen and W. E. Miller. Sta. Paper 83, 12 pp., illus. 1960.

Streambank Stabilization in Michigan--A Survey, by W. D. Striffler. Sta. Paper 84, 14 pp., illus. 1960.

Pulpwood Production in Lake States Counties, 1959, by Arthur G. Horn. Sta. Paper 85, 13 pp., illus. 1960.

Evaluating the Growth Potential of Aspen Lands in Northern Minnesota, by R. O. Strothmann. Sta. Paper 86, 20 pp., illus. 1960.

The Climatic Distribution of Blister Rust on White Pine in Wisconsin, by E. P. Van Arsdel, A. J. Riker, T. F. Kouba, V. E. Suomi, and R. A. Bryson. Sta. Paper 87, 34 pp., illus. 1961.

The Forest Insect and Disease Situation, Lake States, 1960, by Gerald W. Anderson and Donald C. Schmiege. Sta. Paper 88, 18 pp., illus. 1961.

Forest Recreation in the Upper Great Lakes Area: Proceedings of a Seminar on Research Needs, May 11-13, 1961. Sta. Paper 89, 104 pp., illus. 1961.

Wisconsin's Forest Resources, by Robert N. Stone and Harry W. Thorne. Sta. Paper 90, 52 pp., illus. 1961.

Field Calibration of a Neutron-Scattering Soil Moisture Meter, by Richard S. Sartz and Willie R. Curtis. Sta. Paper 91, 15 pp., illus. 1961.